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BIRD BANDING IN NORTH AMERICA: THE FIRST HUNDRED YEARS

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Use of Bird-Banding Information to Investigate Disease, Safety, and Economic Issues of Birds and Their Interactions with Humans

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Abstract.—Bird-banding efforts and the systematic collection and availability of banding data provide valuable information on the breeding sites, local movements, habitat use, migratory pathways, and wintering destinations of many species of birds. These data can reveal information about transmission, maintenance, and movement of pathogens; the bird species and populations responsible for agricultural damage, depredations, and nuisance; and safety hazards of birds related to air travel and other human activities. Banding recoveries help define the residency status of bird species in specific locations and the status varies within species and among populations. The residency of birds is a major factor in determining their role in local transmission cycles of certain diseases. The high fidelity of some bird species to breeding areas makes them good candidates to annually reintroduce and maintain disease agents within a disease focal area and band-recovery information on sampled birds helps define which species are important hosts. Sampling and testing blood samples from multiple captures of banded birds provides valuable information on local disease transmission rates and seasonal patterns for the principal host species and helps identify the habitats and locations where diseases occur. Accumulation, summary, and analysis of bird-banding records from multiple species in a migratory flyway, combined with testing samples from these species, help identify which bird species are potential disseminators of diseases, when and where dissemination is likely to occur, and the source and destination of the disease pathogen. Some avian species seriously impact agricultural production of crops as well as pose human safety problems. Banding operations enable researchers to identify responsible species and populations and to determine seasonal movement patterns, staging areas, population numbers, and reproduction and survival rates in order to better develop effective methods to alleviate these affects. The specific identification of individual birds permits focused investigations on their role in disease ecology, agricultural depredation, and human safety.

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The specific identification of individual birds achieved through the use of numbered leg bands has added great value to a number of investigations on the involvement of birds with, and their role in, diseases of public health, domestic animal health, and wildlife health importance. It has also aided in the investigations and mediation of agricultural depredation, and investigations related to human safety hazards caused by birds. Banding records provide information to determine avian life history characteristics important for these investigations such as: residency status of local species; fidelity and tenacity of species to both breeding and wintering sites; population estimates; survival rates; habitat use; local and regional movement patterns; dates, routes, and speed of migration; and location of breeding and wintering sites. Banding recoveries have been most useful in delineating characteristics related to regional and migratory movement of birds; whereas, recaptures of banded birds at the banders' own study sites provided information on local life history characteristics and comprised most of the banding returns. Certainly the advent and use of radio telemetry has supplemented and in some cases replaced banding returns in describing specific life history characteristics, in identifying specific movement patterns or in determining precise habitat preferences. However, the bulk of information will continue to be obtained from banding records because only a limited number of birds can be fitted with transmitters and tracked.

BANDING INFORMATION FOR DISEASE INVESTIGATIONS

One of the earliest uses of banding information in the investigation of diseases was the ornithological work by H. E. McClure as part of a comprehensive study on the epidemiology of the arthropod-borne viral encephalitides in Kern County, California, in 1943-1952 (McClure et al. 1962). This study related information on avian ecology with the epidemiology of several human and equine viral diseases for which avian species were the primary natural hosts and mosquitoes the principal vectors. The value of studying wild bird populations through mist-netting and banding during disease studies gained more popularity (Stamm et al. 1960) and became an integral part of disease investigations (Lord et al. 1973). There are many important diseases of birds that have an impact on human health (zoonotic diseases), domestic animal health, and wildlife health, but zoonotic diseases have received the most attention (McLean 1991; Friend and Franson 1999; Charlton 2000) (Table 1). Many disease investigators have used banding operations to aid in their studies and a few examples will be described.

Investigations of avian malaria.—One of the most common avian diseases of North American birds is avian malaria which is caused by a single-celled protozoan in the genus *Plasmodium*. Avian malaria is normally a benign disease transmitted between birds by mosquitoes, causing few problems except under certain circumstances and/or with a few species (e.g., impact on endangered Hawaiian bird species). R. D. Manwell described malaria in birds and its relationship to migration and life history habits of birds (Manwell 1934, Manwell and Herman 1935). Numerous investigations were conducted in subsequent years to determine the distribution of avian malaria and host species involvement. In

Table 1. Important diseases of birds of public health, domestic animal health, and wildlife health concern in the United States and the methods of transmission and disease impact.

DISEASE	METHOD	HUMAN	DOMESTIC	WILDLIFE
<u>VIRUSES</u>				
West Nile virus	Mosquito	High	High	High
Western equine encephalitis	Mosquito	High	High	Low
Eastern equine encephalitis	Mosquito	High	High	Low
St. Louis encephalitis	Mosquito	High	None	None
Newcastle disease	Direct	None	High	Low
Avian influenza	Direct	None	High	None
Highlands J	Mosquito	None	Low	None
Avian pox	Mosquito	None	Moderate	High
<u>BACTERIA</u>				
Lyme disease	Tick	High	None	None
Mycoplasma	Direct	None	Moderate	High
Avian TB	Direct	Low	Moderate	High
<u>PROTOZOA</u>				
Avian malaria	Mosquito	None	Low	Low

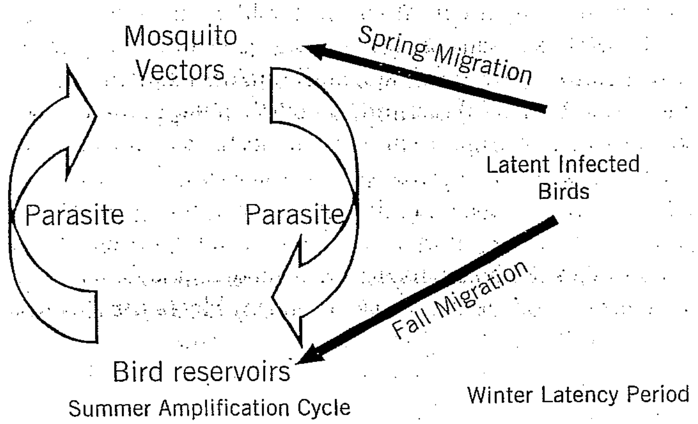

Figure 1. Transmission cycle of avian malaria in free-ranging passerine birds in the United States.

temperate climates in northern latitudes, parasite transmission and increases in bird infections (amplification) occur only during the summer months when vector mosquitoes are active and feeding on birds (Figure 1); however, the disease is able to persist in local bird populations during summers with greatly reduced mosquito activity. The mechanism by which mosquito-transmitted pathogens survive during the winter and during other times when mosquitoes are not active was a puzzle and was critical to the pathogen's long-term maintenance. As part of a five-year, year-round study of bird populations at a permanent study site in central Pennsylvania, the prevalence of avian malaria was determined by examining blood smears from a large number of permanent and summer resident species of birds for parasites (Beaudoin et al. 1971). The American Robin (*Turdus migratorius*), Northern Cardinal (*Cardinalis cardinalis*), and Wood Thrush (*Hylocichla mustelina*) had the highest prevalences of infection of the frequently captured species; 44%, 17%, and 16%, respectively. The prevalence of detectable infections in birds began to increase with the seasonal emergence of adult-feeding mosquitoes in the spring, peaked during the summer amplification period, and declined to undetectable in the fall. A high frequency of recaptures of individual birds at the study site allowed serial testing of

birds for malaria infection within the same summer transmission season and during subsequent years. This serial testing identified when each bird became infected initially at the site, followed their infection status through the summer, and detected the disappearance of parasites from the blood of these birds in fall. Banding had the additional benefit of limiting the number of blood samples taken from individual birds during each sampling period to reduce the risks of extra handling as well as not inflating the infection results from birds that are frequently recaptured.

Because of the high fidelity of species like the American Robin and Wood Thrush to breeding sites, a number of individual birds banded and tested during previous years were tested again in the spring for malaria. Previously infected birds relapsed following the stressful migratory and reproductive periods making malaria parasites available in their blood again to infect emerging mosquitoes. Multiple infected birds relapsed simultaneously to initiate the local summer transmission cycle thus providing a maintenance mechanism for the local survival of the parasites despite the departure of the vertebrate host during the winter months (Figure 1). This chronic infection and relapse phenomenon in the natural avian host species provides for the maintenance of the parasite even through summers with insufficient mosquito production to amplify transmission. The measurement of local movement patterns through recapture information also identified specific habitats that supported malaria transmission.

Investigations of St. Louis Encephalitis virus.—An extended investigation of the avian hosts of St. Louis encephalitis (SLE) virus in the urban environments of southern California during 1987-1996 used banding information from 52,629 birds captured and tested for infection with SLE virus (Gruwell et al. 2000). The virus is transmitted by mosquitoes between birds and occasionally spills over into associated human populations (Figure 2). A small human epidemic of SLE virus occurred in this area of southern California a few years prior to the study and a number of bird species and sites where transmission occurred were identified (McLean et al. 1988). During the later study, the highest capture rate as well as the highest recapture rate occurred in two urban species; House Finches (*Carpodacus mexicanus*) and House Sparrows (*Passer domesticus*). The large capture of 25,599 House Finches (37% recaptures) and 18,214 House Sparrows (42.5%)

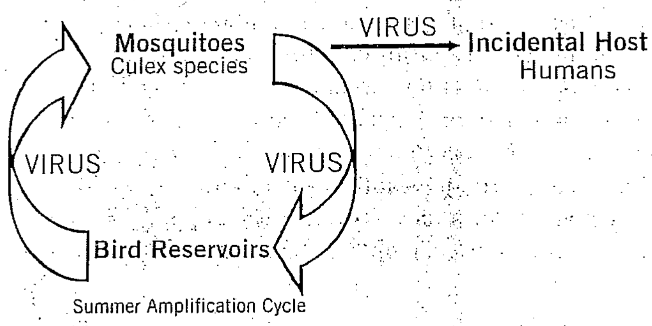

Figure 2. Transmission cycle of St. Louis encephalitis virus in the United States.

occurred because of their high densities, site fidelity, and short movement range. Only 1.1% of the birds were antibody positive for SLE virus, but the high recapture rate allowed for multiple serial bleeding of individual birds to test for conversions from negative to positive infections and to follow infections to define the temporal nature of virus transmission. The short movement distances of these species and little exchange between capture sites as determined by recapture information allowed for spatial separation of the disease data and identification of precise locations where virus transmission by mosquitoes was occurring.

The recapture information was used to calculate the average minimum longevity of each species; 714 days for House Finches and 559 days for House Sparrows. Age and longevity of avian hosts are important factors in understanding the epidemiology of SLE virus; e.g., understanding the effect of population turnover rates on the number of susceptible birds in the local population, which in turn affects the transmission potential of various host species. The banding information in this comprehensive study identified not only the crucial bird species for virus transmission (House Finch and House Sparrow) in this urban environment, but also the precise locations where the virus was optimally transmitted and maintained and the time periods when transmission occurred.

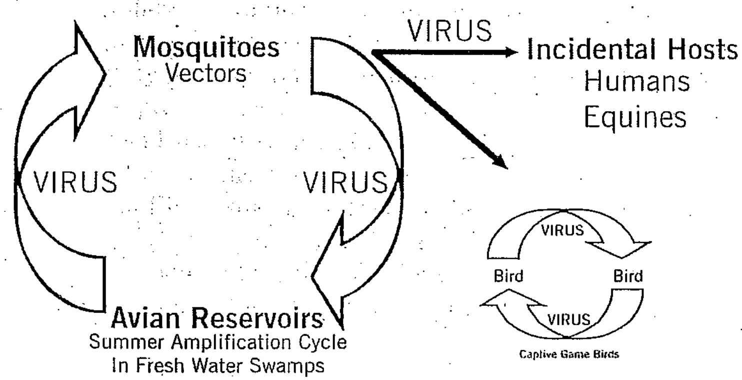

Figure 3. Transmission cycle of eastern equine encephalitis in the United States.

Investigations of eastern equine encephalitis virus.—An ecological study of eastern equine encephalitis (EEE) virus in avian communities in New Jersey freshwater swamps was conducted from 1980-1983 (Crans et al. 1994). This virus transmission cycle involves passerine birds and a specific mosquito vector (*Culiseta melanura*) in selected freshwater swamps along the Atlantic and Gulf coasts of the U.S. Virus transmission occurs during the summer and is restricted to coastal fresh water swamps (foci) where EEE virus is optimally transmitted and maintained because of specific mosquito and avian host species that inhabit the swamp habitats (Figure 3). The virus occasionally escapes from the swamp habitats and causes small numbers of human and equine cases annually and sporadic outbreaks. Historically, EEE virus was also introduced from the swamp foci into captive breeding farms for exotic game birds causing outbreaks that were perpetuated directly between birds by pecking and cannibalism. The use of vaccines, plastic protectors to prevent pecking, and improved sanitary conditions reduced the incidence of such outbreaks. During the study, 1848 individual birds of 69 species were captured and tested for virus and antibodies against EEE virus in a swamp that was a well-established enzootic focus for the virus. Nineteen (1%) birds were viremic (circulating virus in blood) at the time of capture, 494 (27%) birds were antibody positive, and 47 (68%) species were antibody positive for EEE

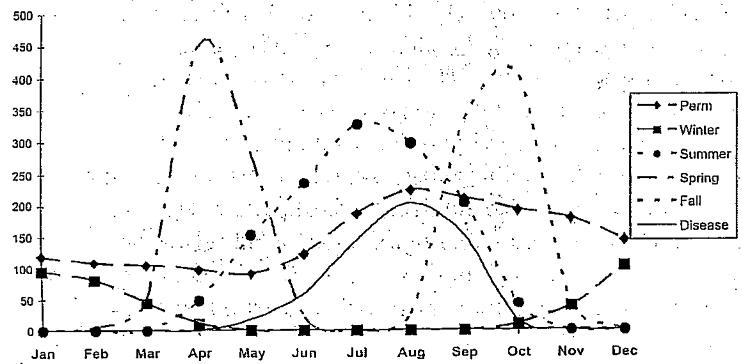

Figure 4. Hypothetical numbers of birds for various residency types at a local fresh water swamp habitat in relation to time periods for mosquito activity and disease transmission of eastern equine encephalitis virus.

virus. Because EEE virus is not transmitted throughout the year in swamp habitats in the northern latitudes (adult mosquitoes die or are inactive during the winter months), residency status of many bird species was critical in defining their role in amplifying and sustaining virus transmission (Figure 4). Banding information determined which species were locally important as host for the virus and determined the type of local residency status that was most closely linked to participation in the EEE transmission cycle. Avian species and subpopulations of species spending the greatest amount of time in the swamp in the summer had the highest prevalences of EEE antibody; permanent resident Blue Jay (*Cyanocitta cristata*) (62%), Tufted Titmouse (*Baeolophus bicolor*) (44%), and Carolina Chickadee (*Poecile carolinensis*) (39%), and summer resident Wood Thrush (60%), Gray Catbird (*Dumetella carolinensis*) (34%), and American Robin (30%). Transient migrant and winter resident birds had the lowest antibody prevalences.

As with the SLE study, serially testing of individually banded birds over time at the study site provided insights on the epidemiology of the disease not otherwise achievable. Band recoveries on birds tagged and sampled the previous year (69 birds, 4%) identified 29 of the recaptured birds (42%) that had seroconverted from antibody negative to positive; 12 (17%) seroconverted in the spring before EEE virus was detected in local mosquitoes. One Gray Catbird was antibody positive in May, 1981 and was viremic and thus capable of infecting mosquitoes when recaptured the next year on 8 June 1982. The banding information combined with serial sampling of individual birds enabled researchers to postulate that mosquito-transmitted viruses are able to survive through temperate winters when there is no mosquito activity as persistent and relapsing infections in birds to initiate early summer transmission cycles.

West Nile virus dissemination by migratory birds.—A strain of West Nile virus (WNV) introduced into New York City in 1999 caused a human epidemic and an epizootic in the local bird population (Eidson et al. 2001). This mosquito-transmitted virus of birds became established in the northeastern states and then rapidly expanded across the country within three years. By the fall of 2004, the virus was present in all of the continental 48 states (CDC 2004). The dissemination of WNV was most likely facilitated by the seasonal movement of migratory birds (McLean 2002). An investigation into the involvement of migratory birds in the spread of WNV was initiated in 2001 and more than 13,000 wild birds from 139 species at 17 sites in 12 states were captured and sampled (R. McLean, S. Guptill, and R. Dusek, unpublished data). Banding information combined with laboratory results from testing blood samples from this study will be used to determine which bird species are potential disseminators of the virus and the routes of dissemination. This information will be supplemented by the accumulation, summary, and analysis of historical bird-banding records to further define the avian host species, to predict when and where dissemination is likely to occur, and to evaluate the likely source and destination of the virus.

BANDING INFORMATION FOR INVESTIGATIONS OF BLACKBIRD DAMAGE TO AGRICULTURAL CROPS

Bird banding of some avian species that seriously impact production of agricultural crops enables researchers to identify responsible species and populations, determine seasonal movement patterns, determine staging areas, and evaluate prevention strategies. Blackbirds are a group of species that have negatively impacted agricultural production.

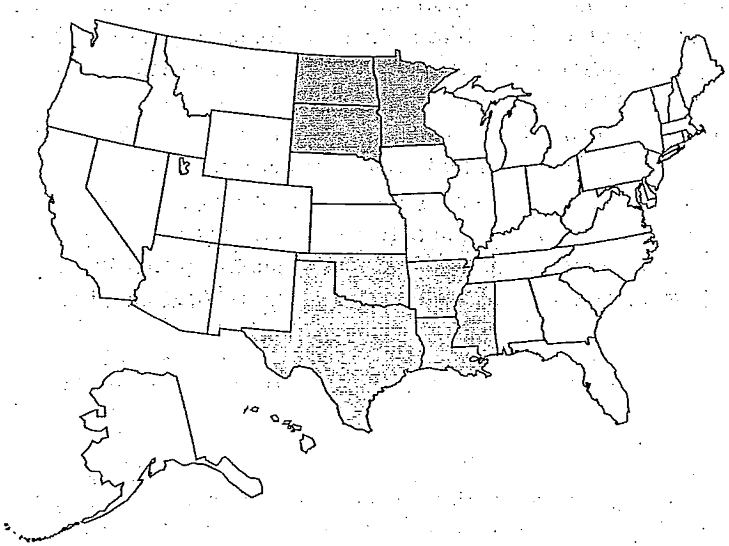

Figure 5. Locations of breeding populations in the north-central states and wintering populations in the south-central states of Red-winged Blackbirds that cause significant agricultural damage in the United States.

Blackbird populations have thrived in response to agricultural changes in the north-central and south-central states. Ripening sunflower crops in the north in the fall (Cummings et al. 1989) and rice crops in the southern states in the winter (Brugger and Dolbeer 1990) receive heavy blackbird depredation resulting in millions of dollars of damage. Changes in the prairie pothole wetlands in the northern Great Plains to dense stands of cattails made this area desirable for nesting and roosting blackbird populations and wintering flocks of blackbirds extend across the southern states supported in part by the winter rice crops (Figure 5). Bird-banding records indicate that the breeding and wintering Red-winged Blackbird (*Agelaius phoeniceus*) populations are linked (Brugger and Dolbeer 1990). Banding recoveries revealed that individual populations of blackbirds tend to stay together during the winter months in southern states and specific roosts were located that

contained banded birds from the sunflower damage areas in the Dakotas. The banding information allowed mass marking of the large identified blackbird roosts with aerially applied dyes to track the movement and destination of wintering blackbirds to the summer breeding grounds in the north (Knittle et al. 1987). Banding recoveries over five years indicated the fidelity of male blackbirds to specific breeding territories in the Dakotas (J. L. Cummings, unpublished data). This banding information enables researchers to identify specific wintering roosting sites in the south and migratory routes and staging areas of these same birds between their wintering grounds and breeding range in the north which allowed targeted management efforts to reduce specific crop depredation.

BANDING INFORMATION FOR INVESTIGATION OF AIRLINE SAFETY HAZARDS FROM BIRD STRIKES

Hazards to public safety from aircraft strikes of wildlife, especially birds, has steadily increased during the last few decades. Crashes of commercial and military aircraft have resulted in hundreds of deaths and significant economic loss to the airline industry and the military. Management strategies to reduce the number and frequency of strikes at airports included habitat management, bird deterrents, noise and visual harassment techniques, and shooting. The situation at John F. Kennedy International (JFK) Airport in New York City (NYC) was of particular concern because of an airline crash, airplane damage (especially to the Concorde), and an increasing number of bird strikes to airplanes (Figure 6). An expanding breeding colony of Laughing Gulls (*Larus atricilla*) adjacent to the JFK airport increased from 15 pairs in 1979 to 7629 pairs in 1990. In analyzing the bird strike data, Dolbeer et al. (1993) determined that 52% of the bird strikes were from Laughing Gulls, 35% from other gull species, and 13% from other bird species. All of the bird strikes due to Laughing Gulls were from May to September during the breeding season. Habitat management to reduce the local presence of Laughing Gulls was not possible because the large breeding colony was located in the Jamaica Bay Wildlife Refuge adjacent to the airport. The gulls flew from the breeding colony across the airport to multiple foraging areas in the NYC area. Shooting of gulls flying on the airport runways became the only viable option to reduce air strikes. Collection and

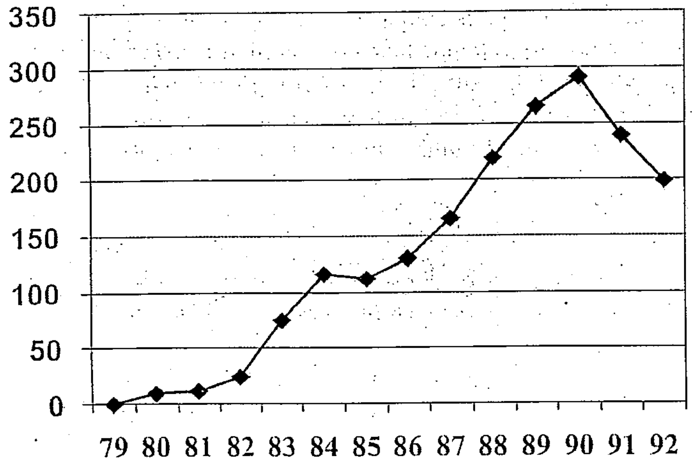

Figure 6. The number of bird strikes with airplanes at the John F. Kennedy International Airport, New York City, New York, 1979-1992 (modified from Dolbeer et al. 1993).

examination of the gulls shot at JFK airport during 1991-1992 revealed that 92% were Laughing Gulls of which 90% were brooding adult birds likely from the adjacent breeding colony since the nearest other breeding colony was 106 km away. Population control resulted in 68-89% reduction in airplane strikes during the first 2 years of the shooting program (Figure 6). Gulls shot were representative of gulls struck by aircraft as determined by the banding records of the birds. A similar percentage of the Laughing Gulls struck (2.4%) and the Laughing Gulls shot (2.2%) were banded and both groups had a similar species composition and age-sex ratios indicating that the shooting was specifically directed at the gulls causing the strikes. Of the banded gulls, 98% were banded as nestlings in New Jersey, 106 km from JFK; no banding of nestlings was occurring at the local breeding colony.

SUMMARY

The benefits of bird-banding information to disease investigations, regional investigations of depredation of agricultural crops, and investigations of human safety issues at airports have been illustrated. The greatest benefit from combining bird-banding operations with other investigations is during multiyear sampling studies in specific locations when a high frequency of multiple recaptures occur. The identification of individuals by banding and multiple serial sampling of tagged individuals provided the most useful tool in understanding disease dynamics in local bird populations. Historical banding information can be used in determining potential dissemination routes of diseases of wild birds. Bird-banding information can be complemented by radio telemetry to track both short-distance and long-distance movement patterns (satellite telemetry) and by stable isotope studies to determine the geographical breeding locations of fall migrants and even locations visited.

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